

of lunar or solar hours (Mondbeziehungsweise Sonnenstunden) which have elapsed since the last upper culmination of either body respectively; then the theoretical elevation or depression of the sea in the Gulf of Fiume due to these causes for any given time is found in millimetres by the expression:—

$$112.1 \frac{\cos \frac{2\delta_m}{3} \cos \frac{\pi}{6} (t_m - 8.49)}{\rho_m} + 272.4 \frac{\sin \frac{2\delta_m}{3} \cos \frac{\pi}{12} (t_m - 4.60) + 60.3 \frac{\cos \frac{2\delta_s}{3} \cos \frac{\pi}{6} (t_s - 8.57)}{\rho_s} + 130.4 \frac{\sin \frac{2\delta_s}{3} \cos \frac{\pi}{12} (t_s - 4.46)}{\rho_s}$$

This is the theoretical amount, not allowing for any local retardation, or any influence of the weather.

The author has calculated this for a great variety of conditions of the variable quantities, and compared them with the results of observations, and the comparisons have always been satisfactory.

He gives comparative pairs of curves, one drawn by the tide-gauge, the other calculated by the formula, and the striking resemblance is at once appreciable by the eye. The coincidence would be still nearer if the influence of the small sidereal-time variations were added.

The mean amplitudes of the four chief oscillations are as follows:—

|                                           | Millimetres. |
|-------------------------------------------|--------------|
| For the oscillation of twelve lunar hours | 103.2        |
| For that of twelve solar hours            | 55.7         |
| For that of twenty-four lunar hours       | 130.5        |
| For that of twenty-four solar hours       | 62.4         |

The maximum amplitudes are:—

|                                           |       |
|-------------------------------------------|-------|
| For the oscillation of twelve lunar hours | 132.8 |
| For that of twelve solar hours            | 60.9  |
| For that of twenty-four lunar hours       | 272.2 |
| For that of twenty-four solar hours       | 100.2 |

The author shows how the variable combinations of these several elements determine and account for the peculiar phenomena observed, and he explains in what particulars the circumstances at Fiume would appear to differ from those in other places, and to give rise to special phenomena peculiar to that locality.

He further devotes particular attention to the explanation of the singular daily retardation, which he states has also been noticed by M. Aimé on the coast of Algeria, although it had been erroneously ascribed by him to the effect of the wind. The real cause he shows to be the oscillations depending on sidereal time.

The non-periodical motions of the water are caused chiefly by variations in the direction and force of the wind, and in the barometer-pressure. The temperature of the sea rain, and storms, may have also some influence, but too slight to require investigation.

The author therefore confines his attention to the wind and the pressure of the air. In regard to the former, looking at the form and position of the Gulf of Quarnero, it is evident that southerly winds will force the water into the cul-de-sac towards Fiume, and so will raise the level, while northerly winds will tend to drive the water out of the gulf, and so lower the surface.

In regard to the barometer-pressure, it is pointed out that if the weight of the atmosphere at any given part of the sea differs from that at another part some distance away, there must be a corresponding difference in the level of the water; and this difference will be propor-

tional to the specific gravities of the two fluids:—thus a difference in the barometer of one inch of mercury will cause a difference of level of about  $13\frac{1}{2}$  inches in the water.

The effects of these two influences are involved in various complications, but they are sufficiently proved by the records, and their amount is shown to be considerable.

The following facts shown in the records will give some general idea of the extent of the Mediterranean tides; we believe they are pretty much the same in all parts of the sea.

The highest water level known was on Dec. 26, 1870, being 0.870 metres above a certain datum point; the lowest was on Jan. 11, 1869, being 0.482 metres below the same point. Hence the greatest difference of level experienced was 1.352 metres, or about  $4\frac{1}{2}$  English feet.

The average daily variation of level was 0.583 metres, or nearly two feet English; the greatest daily variation was 0.825, and the least 0.259 metres.

The mean daily variation of level is the same, whatever be the absolute general level of the water; as is natural, seeing that the latter is influenced by local circumstances that have no effect on the attractions of the sun and moon.

The mean high and mean low water stand at equal distances above and below the average mean level.

The author modestly expresses the opinion that his own three years' observations are of too limited extent to determine fully the values of all the influences which affect the tides, and he recommends that before the investigation is carried further, accurate observations should be made at other points of the Adriatic Sea, in order that, by a combination of such data, the distinction between normal and exceptional phenomena may be more positively defined. No doubt such an extended inquiry would give results of great value to physical science, and M. Stahlberger's excellent example is not unlikely to stimulate others to co-operate in such an undertaking.

The book is well got up. It is written in the national language, but there is also given a translation into German, and the data, in the form of tables, are so full and complete as to enable anyone to verify, by his own examination, the conclusions arrived at by the author.

#### OUR BOOK SHELF

*Cambridgeshire Geology; a Sketch for the use of Students.*

By T. G. Bonney, F.G.S., Tutor and Lecturer in Natural Science, St. John's College. Cambridge: Deighton, Bell, and Co., 1875.)

MR. BONNEY's short sketch of the geology of the neighbourhood of Cambridge will be a useful handbook to those students who wish to become practically acquainted with the geological features of the country round their temporary home. It makes no pretensions to be an exhaustive description, and happily is not written in a style suitable for cramming, but simply draws the attention of the careful reader to all the interesting points in connection with the geology of the district, and notices the various contributions to fact or theory made by previous writers, embodying many of Mr. Bonney's own observations. The first deposits described are the Oxford clay of St. Ives and the Elsworth rock, the true position of which latter is discussed; and then follows a notice of

the coral reef at Upware, and the Kimmeridge clay at Ely. We have next a discussion of the coprolite and associated beds at Potton and Upware, which Mr. Bonney considers Upper Neocomian, and he thinks most of the fossils derived. After a short notice of the Gault comes a full discussion of the interesting questions connected with the so-called Upper Greensand. An admirable outline of its palæontology is first given, and the origin of its phosphatic nodules is then concluded to be analogous to that of flint, or what is here called concretionary action. With regard to its age, Mr. Bonney follows Mr. Jukes-Browne in considering it homotaxial with the chloritic marl, and a large part of its fossils derived from the Upper Gault. The chalk is dismissed with a very short notice, and an account of the Post Pliocene deposits concludes the sketch. These deposits are described under six divisions, the lowest being the true Boulder Clay. The most interesting of these is the "Fine Gravel of the Plains," which has yielded so many mammalian remains. Five appendices follow: on Upware sections, the Ely pit, the Hunstanton red rock, the water supply, and building stones of Cambridge. The second of these might well have been omitted, for though it refers to an interesting case of a large chalk boulder, we are now sufficiently familiar with such instances of huge transported rocks to make it waste of time to discuss imaginary systems of impossible faults to account for its presence in some other way.

*Journey across the Western Interior of Australia.* By Col. Peter Egerton Warburton, C.M.G. With an Introduction and Additions by Charles H. Eden. Edited by H. W. Bates. With Illustrations and a Map. (London: Sampson Low and Co., 1875.)

COL. WARBURTON well deserves any honours which he may have received; for the sake of increasing knowledge he has performed as bold a feat of travel as is on record. With his son, Mr. J. W. Lewis, two Afghan camel-drivers, and two natives, he set out on April 15, 1873, from Alice Springs, in E. long.  $133^{\circ} 53' 14''$ , S. lat.  $23^{\circ} 40'$ , about 1,120 miles north from Adelaide, and travelled right across the centre of the Australian continent, reaching the western side in January 1874. Col. Warburton's narrative in the book before us consists of the record which he kept day by day of his progress. The party had sixteen camels, and were provisioned for six months. Experience has shown that to explore Central Australia camels alone are of any use, horses being totally unable to bear up against the universal scarcity of water, and the bristling spinifex stalks which cover the ground almost everywhere, and which cut their legs to pieces. Col. Warburton's journal, not long after the start, becomes a painful record of a daily hunt after water, a hunt which was often unsuccessful. During the greater part of the journey man and beast were in a chronic state of parching thirst. The country crossed over is as arid and desolate a wilderness as can well be conceived, consisting mainly of low sandy hills covered almost everywhere with the above-mentioned spinifex, occasionally varied by a salt marsh, a few hills, and rarely a few trees. Indeed, the whole country from  $121^{\circ}$  to  $131^{\circ}$  E. long. is one great sandy desert. Bustards, one or two species of pigeons, owls, rats, a small species of kangaroo, swarms of torturing flies and ants, were met with, the last-mentioned with painful frequency. Natives were also seen, and they proved perfectly harmless and generally shy, and some of them Col. Warburton describes as handsome and well made.

The general method of procuring water was to scoop out wells in the sand, and it was only at long intervals that suitable places occurred. The food supplies of the party were very soon exhausted, and they had for the greater part of the journey to live on roots, an occasional "wallaby" (small species of kangaroo), and on the camels which they were compelled to kill. Of the fourteen camels, only two reached the journey's end, some

having been lost, some left behind as unable to move, and seven killed for food. The flesh of the latter seems to have been as tough and devoid of nourishment as leather, and by the time the party reached the welcome river Oakover they were all nearly on the point of starvation; latterly, Col. Warburton himself had to be tied on his camel's back. On reaching the Oakover, some of the party pushed on to the settlement for relief, which at last came, and Col. Warburton met with an enthusiastic reception everywhere from Roeburne to Perth and on to Adelaide. He has made a valuable contribution to our knowledge of Central Australia, and as the spirit of exploration seems to be thoroughly aroused in the colony, we may hope soon to have its geography at last filled up. The difficulties and dangers of Australian exploration are well known, and by forethought and organisation no doubt they might be successfully met. It seems doubtful whether any economic use can ever be made of the arid wastes of Central Australia, but a thorough knowledge of its natural history and geology would be of high value from a scientific point of view. All the expenses of Col. Warburton's journey, we should say, were generously borne by the Hon. T. Eden and Mr. W. W. Hughes, public-spirited Australian colonists.

The introduction occupies about one-half of this volume, and consists of a carefully compiled and most interesting *résumé* of Australian exploration from Eyre's daring journey in 1840 downwards; it adds much to the value of the work. Mr. Bates has discharged his editorial duties satisfactorily. A good portrait of Col. Warburton is prefixed, and the map gives one an excellent idea of the route as well as of the nature of the country. The other illustrations are rude but interesting. Altogether the volume is a valuable contribution to the history of Australian exploration.

## LETTERS TO THE EDITOR

[The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.]

### Acoustic Phenomenon

PERHAPS the following description of a phenomenon in sound which I have frequently observed may be of some interest to a few of your readers:—

If an observer is placed a short way, say about eight yards, in front of a straight palisaded fence made with deals of about three inches in width and about six inches from centre to centre apart, so as to leave intervening spaces of three inches, and then gives a smart clap with his hands, or, what is better, with two flat pieces of wood, a peculiar echo is heard almost at the same instant.

The nature of the sound is neither that of a true musical note nor of an inflection; it appears to the ear to be somewhat intermediate to those, inclining more at the beginning, when well elicited, to a very high-pitched sound of the latter kind; it slides down until it becomes a distinctly audible musical sound at the end, if the fence is 80 or 100 yards long; with those dimensions a moderately quick ear can easily recognise the pitch of the final note to be near D on the fourth line of the treble clef.

The phenomenon is caused by each board of the fence giving rise to a resonance; those aerial impulses succeed each other at constantly increasing intervals of time, and with such a degree of rapidity as to constitute a continuous sound of the kind which is here described. The vibrations will be seen, from the following diagram, to be neither isochronous like those of a musical sound, nor to vary in their periods in the same simple order as those of an inflection which is produced by sliding the bridge of a monochord while it is vibrating.

Let  $o$  be the position of the observer, and  $d_1 d_2 d_3$  &c. the boards of the fence.

Call the distance  $o d = D$ , and  $d d = \delta$ . Then by the common rule for right-angled triangles the distances of each board from the observer are respectively  $\sqrt{D^2}$ ,  $\sqrt{D^2 + \delta^2}$ ,  $\sqrt{D^2 + 4\delta^2}$ ,